Volume 3 MAY, 1924 Number 5

JOURNAL

OF THE

AMERICAN WELDING SOCIETY

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33 West Thirty-ninth Street, New York

American Welding Society

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AMERICAN WELDING SOCIETY

ESTABLISHED 1919

JOURNAL

Volume 3 May, 1924 Number 5

OUR PRESIDENT
ERIC HAROLD EWERTZ

At the annual meeting E. H. Ewertz was elected president of the American Welding Society. He is a native of Sweden, where he was born

E. H. EWERTZ

at Karlskrona, June 3, 1873. Having attended the grammar and high schools in his home town, Mr. Ewertz entered the Mechanical Engineers College at Malmo, Sweden and graduated on his eighteenth birthday. He then went to Berlin, Germany, in order to continue his studies.

Going afterward to the United States, Mr. Ewertz located in Elizabeth, where he held the position of chief of construction at the Crescent Shipyard. He left this to become superintendent of the hull and engineering departments at the Fall River Shipbuilding Corporation of Quincy, Mass., having charge of all submarine boat construction and later becoming general superintendent of the Fall River plant. Mr. Ewertz accepted the position of General Superintendent of the Bethlehem Shipbuilding Corporation plants at Squantum, Mass., and after a time was transferred to their large plant in Elizabeth as General Manager, where he is now located.

Mr. Ewertz was one of the founders of the American Welding Society, having become identified with the welding movement during the war as one of the active members of the Welding Committee of the Emergency Fleet Corporation. Recognizing its possibilities, he has been one of the most loyal supporters of welding and active in promoting the affairs of the Society. He served for two years as Chairman of the New York Section. One of the outstanding accomplishments of the Electric Arc Welding Committee is a critical review of existing information on the application of arc welding to ship construction. This work has been due to the untiring efforts of Mr. Ewertz. We are fortunate indeed to be able to secure as our leader a man of the ability, standing and reputation of Mr. Ewertz.

IMPORTANT NOTICE

The Membership Directory of the American Welding Society will be printed as the August, 1924, issue of the Journal. In order to get this issue out in time it will be necessary for us to have all the material in the hands of the printer by the 1st of July.

This directory is a blue book of those identified with the welding industry. If you are interested in welding, it is to your advantage to have your name included. This list will undoubtedly be used as a mailing list by the entire welding fraternity. If your name is not in it you will be out of touch with the latest welding developments.

Members are urged to pay their dues promptly, as it has been decided not to include delinquent members.

The Membership Committee would appreciate it if every member would at once secure at least one new member in order that his name might be included. We should have over 1000 names in this directory as paid-up members of the American Welding Society. It is up to you to do your share. If you cannot convince a prospective member of the advantages of joining the Society kindly send to the Secretary his name and address and we will forward him literature which will give full information concerning our work.

DON'T PUT IT OFF! ONLY A FEW WEEKS LEFT.

SECTION MEETINGS

During the summer most of the local sections of the Society are planning to arrange their programs of meetings for the coming year. In this connection it is desirable to call attention to the responsibility of members.

Take for example the last meeting of the New York Section. The speaker was S. W. Miller, Chairman of the Gas Welding Committee. The subject of his address was "Welding of Manganese Steel." In order to secure the information for the members of the Society, Mr. Miller and his company was put to a great deal of expense in both time and money. An idea of the value of the paper as presented can be gained by reading it elsewhere in this Journal. Although about 800 notices were sent out to those who should be interested in this subject the attendance was approximately sixty.

The above is given as an illustration of the lack of courtesy and appreciation shown by a great number of our members to the speakers and officers of their section. Mr. Miller, for example, has an international reputation as an authority on welding matters. It is a privilege to be able to profit of his knowledge and experience simply by spending a few hours.

Of course members may argue that they can read the paper afterward in the Journal of the Society. In answer, however, it should be pointed out that not all papers presented before Section meetings are published by the Society, and very rarely are the discussions included. For example, in the instance cited there was fully as much information brought out in the answers to questions given by Mr. Miller and J. H. Hall of the Taylor-Wharton Iron and Steel Company as in the article itself. Again, it should be pointed out that the officers of the Sections spend a lot of time in arranging for meetings for which time they do not receive any returns except the satisfaction of knowing that they are helping to boost the welding industry. The least that our members can do is to attend the meetings and participate in the discussion.

It may be interesting to compute the cost of such a meeting to the American Welding Society, exclusive of the time of the speakers and officers of the section, and the cost of the investigation which, of course, the Society could not hope to pay for. The meeting room in this instance cost $40. The time of the lantern slide operator, $7.50. Time, material and postage for mailing 800 notices, $64. The total is $111.50. There were about sixty members in attendance, making the cost per member $1.85. If, as should have been the case, 300 members were in attendance the cost per member would have been $0.37.

Annual Meeting

The fifth annual meeting of the American Welding Society was the most successful since its organization in 1919. The Society is now established on a firm foundation. Although its growth has not been by leaps and bounds as originally anticipated, nevertheless its sure steady climb is a source of gratification to all its members.

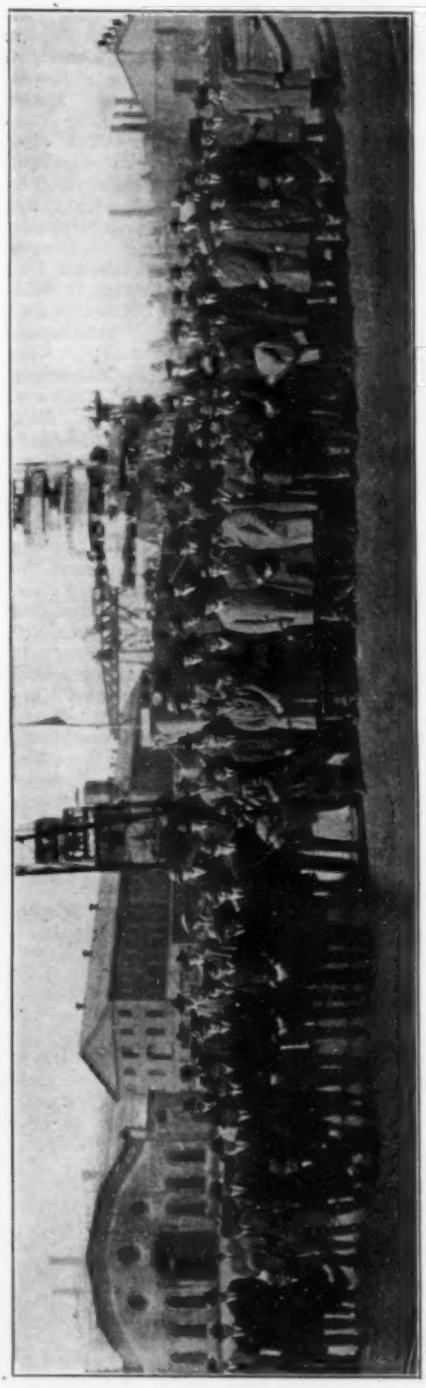
The meeting opened on Wednesday morning with a session of the research committee on Resistance Welding of the American Bureau of Welding. The progress made by the Committee during the past year was reviewed and the chairman called attention to the fact that the report on the present state of the art of seam welding was completed and published. A report on spot welding, prepared by Mr. Remington, was presented and it was voted to send this out to the members of the committee for their comments. During the coming year it is expected that work will

be continued on the determination of proper chemical and physical composition of metal best suited for resistance welding. Technical information will be compiled regarding electrical energy, time, pressure and selection of materials to be welded by the resistance processes.

The Electric Arc Welding Committee held a meeting Wednesday afternoon. As usual this meeting was well attended by members of the committee and the Society. The report on the application of arc welding to ship construction was completed and published in *Marine Engineering* and was later reprinted as a bulletin of the Society. A critical review on existing information on arc welding of non-ferrous metals was also completed and published. A series of investigations will be made to secure further data on this latter subject. During the coming year it is planned to complete a very comprehensive series of tests started during the war on the fundamentals of arc welding. These samples were made up and carefully machined at the time and sent to the Electrical Testing Laboratories. These samples will now be reshipped to Union College, where they will be tested without charge to the Committee.

The first annual smoker of the Society was held Wednesday evening. Those who were there will remember very pleasantly the enjoyable evening spent on this occasion. The master of ceremonies was C. J. Holslag. There were smokes, pretzels and a "special punch" which helped to make the meeting a success. A very remarkable picture on the part that welding plays in the construction of a modern automobile body was shown by J. W. Meadowcroft of the E. J. Budd Manufacturing Co. A. M. Candy of the Westinghouse Electric & Mfg. Co. entertained the members by reading a specially prepared paper dealing with the humorous aspects of welding and facts concerning the officers and founders of the American Welding Society.

The business session of the Society was held on Thursday morning. The meeting was presided over by T. F. Barton, who presented a report of the year's activities and pointed out the possibilities of the Society. Other reports presented were those of the Meetings and Papers Committee and the research department (American Bureau of Welding). These reports were published in the April issue of the Journal. R. E. Bruckner, chair-



INSPECTION PARTY, A. W. S.

man of the Teller's Committee, reported the unanimous election of the following officers of the American Welding Society: President, E. H. Ewertz, general manager Moore Plant, Bethlehem Shipbuilding Corporation, Elizabeth, N. J.; vice-presidents, Middle Eastern Division, J. D. Conway, secretary-treasurer The Railway Supply Mfg. Assn., Pittsburgh, Pa.; Middle Western Division, Henry S. Mann, district manager Metal & Thermit Corp., Chicago, Ill.; New York and New England Division, T. A. Wry, General Electric Co., Lynn, Mass.; directors: J. H. Deppeler, Metal & Thermit Corp., New York; A. S. Kinsey, Air Reduction Sales Co., New York; E. M. T. Ryder, Third Avenue Railway System, New York; W. A. Slack, Torchweld Equipment Co., Chicago, Ill.

At the meeting of the Board of Directors on Thursday afternoon careful consideration was given to increasing the membership of the Society. During the past year the attention of the officers has been concentrated on accomplishments and the development of organization rather than on securing new members. It was felt that as soon as the Society had to its credit a number of outstanding accomplishments that efforts in securing new members would be very much easier. The time has arrived when the American Welding Society is recognized as the most authentic source for welding information in the world. A number of suggestions were made for increasing the membership which involve the cooperation of every member of the Society. You can expect a request for help very shortly from the Membership Committee. Mr. C. A. McCune and Miss M. M. Kelly, the present Treasurer and Secretary of the Society were reappointed. In addition to the officers, the following members of the Board of Directors will serve as the Executive Committee of the Society; Messrs. H. S. Smith, A. S. Kinsey, E. M. T. Ryder, C. J. Holslag, A. G. Oehler and J. H. Deppeler. The new chairmen of the standing committees are given on the inside of the front cover of the Journal.

About 100 members of the Society and their guests went on an inspection trip Thursday afternoon, to the Brooklyn Navy Yard. The party was escorted through a portion of the main machine shop where Diesel engines are being built for new submarines. Welding plays an important part in the construction of these engines. Manifolds, tees, wye connections, water jackets, etc., are made of thin steel plates fabricated and welded. The New York Navy Yard generates oxygen and hydrogen with an electrolytic equipment, comprising 32-1000-ampere, 25-500-ampere and 24-250-ampere cells, having a total capacity of about 10,000 cu. ft. of oxygen and 20,000 cu. ft. of hydrogen per 24 hr. The oxygen cylinders are periodically tested with an apparatus that indicates the expansion of the cylinder under pressure of 3000 lb. per square inch. The acetylene plant comprises acetylene generators, cylinder inspection, conditioning, and acetone recharging apparatus, and the acetylene compressing pumps and manifolds. The party went on board the Colorado and spent some time inspecting the equipment. The armament comprises 8-16 in. turret guns, 14-5 in. secondary guns, 4-3 in. anti-aircraft guns, and 2-21 in. submerged torpedo tubes. The crew consists of 61 officers and 1565 men. In marked contrast with this magnificent fighting arm of the nation was the melancholy sight presented at the shipways where the North Dakota and the Indiana are being cut into scrap under the direction of Lt. G. J. Shaw, U. S. N., at the rate of about 1000 tons a week. The steel work is cut with oxyacetylene torches to car-shipping size—8 ft. by 22 to 30 ft. Lieutenant Shaw expects to clean up both vessels by July 1. A photograph of the inspection party with the battleship Arkansas and the shipways as a background is shown elsewhere in this Journal.

The third annual dinner of the Society was held Thursday afternoon in the Park Avenue Hotel. About 100 people were present. The annual dinner has come to be looked upon as the outstanding feature of the annual program. On this occasion in addition to the usual professional talent, members were entertained by solos of two of our Past Presidents, Messrs. C. A. McCune and J. H. Deppeler. There were many impromptu speeches made by the Past Presidents of the Society, Officers of Sections and others interested in its welfare. In addition, there were two prepared addresses by Messrs. James Larkin, Assistant to President, Bethlehem Steel Corporation, and Harry Vought, Secretary of the Railway Club, that were both instructive and entertaining.

The annual meeting of the Ameri-

can Bureau of Welding was held on Friday, April 25. The annual report of the Bureau was published in the April issue of the Journal. Several committees that have completed their work were discharged. It is planned during the coming year to organize a new committee seeking to extend the applications of welding in the structural field. Those who were present were of the opinion that the Bureau had reached a new era of development. Its past accomplishments has placed it in a position to undertake large projects which, with the aid of the National Research Council, can be properly financed. Our little American Welding Society, through its research department, the Bureau, is successfully conducting more research work than any other society.

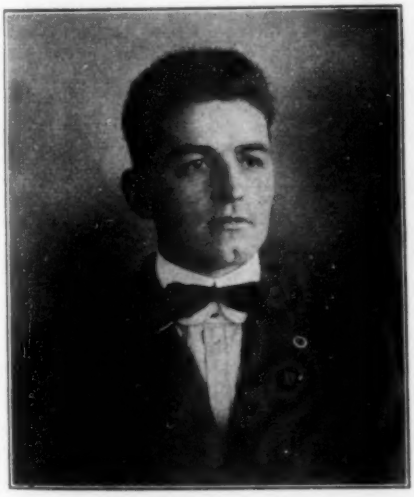
A meeting of the Gas Welding Committee was held on Friday afternoon. Further progress was made on the summary of information on welding of pipe lines. A preliminary report on the welding of manganese steel was prepared by the Chairman and accepted for publication. It appears elsewhere in this journal.

The prediction of the Meetings and Papers Committee that the subject, "Flexibility vs. Rigidity in the Design of Welds," would be of interest to the members of the Society was borne out by the discussion which took place at the technical session Friday afternoon. Five experts, Messrs. J. C. Lincoln, S. W. Miller, C. J. Holslag, H. A. Woofter and J. H. Deppeler treated the subject from the point of view of the several processes of welding. These papers were published in the April issue of the Journal. This session concluded the most successful meeting held by the American Welding Society.

Section Activities

Philadelphia

The annual meeting of the Philadelphia Section was held on April 21st in the Engineer's Club. J. W. Meadowcroft of the E. J. Budd Manufacturing Co. presented a moving picture and lecture on the welding of all steel automobile bodies.



MR. J. W. MEADOWCROFT
Newly Elected Chairman, Philadelphia Section

At this meeting the following officers were elected to serve for the coming year: Chairman, J. W. Meadowcroft; vice-chairman, A. Schroeder; secretary, H. E. Hopkins; treasurer, C. W. Bates.

Chicago

The April meeting of the Chicago Section was held on April 4th in the rooms of the Western Society of Engineers. W. L. Senhert of the Chicago Welded Products Company delivered an address on "Job Welding Shop." His lecture was accompanied by lantern slides showing many large welding jobs performed under his supervision during the past few years. A spirited discussion followed as to the methods and processes involved.

The second paper entitled "Compressed-Dissolved Acetylene" was read by M. A. Dantzler of the Gas Tank Recharging Company.

The May meeting of the Chicago Section was held on May 2nd in the rooms of the Western Society of Engineers. A new motion picture film, "Oxygen, the Wonder Worker," was presented by a representative of the Air Reduction Sales Company. An added feature of the program was the serving of refreshments. This was the last meeting of the Chicago Section.

Pittsburgh

The annual meeting of the Pittsburgh Section was held on Tuesday, April 22nd at the Fort Pitt Hotel. The following officers were elected to serve for the coming year: Chairman, J. D. Conway; first vice-chairman, H. D. Kelley; second vice-chairman, A. M. Candy; secretary and treasurer, H. E. Hollis.

Executive Committee — (To serve for 3 years) A. M. Candy, H. D. Kelley, F. S. Austin, J. A. Warfel; (to serve for 2 years) S. W. Mann, G. H. Danforth, Andrew Smith and E. L. Schaffer; (to serve for 1 year) J. B. Flock, W. M. Finlayson, J. L. Leeper, L. W. Mesta.

A. G. Bissell, general engineer of the Westinghouse Electric and Mfg. Co., addressed the Society on "Arc Welding in a Navy Yard."

New York

No meeting of the New York Section was held in April as it was felt desirable to follow out the policy of regarding the technical session of the annual meeting of the national society as the meeting of the section.

The May meeting was held in the Engineering Societies Building on May 13th, at which time S. W. Miller presented a paper on the "Welding of Manganese Steel." This paper was in reality a report of the Gas Welding Committee of the American Bureau of Welding and is a summary of the conclusions obtained from the investigational work under the supervision of Mr. Miller in this direction. At this meeting the officers for the coming year were elected.

Northern New York—Western New York

The twenty-first meeting of the Northern New York Section was held in the Chamber of Commerce rooms, Rochester, on April 16th. The purpose of this meeting was to assist in the organization of the Western New York Section. B. C. Tracey, chairman of the Membership Committee of the Northern New York Section, presided.

C. A. McCune, treasurer of the National Society, gave a short talk on the organization and the aims of the Society. A motion was passed proposing the organization of a Western New York Section, and the following officers were elected: Chairman, G. W. Swan; vice-chairman, W. B. Miller; secretary-treasurer, Carl D. Miller.

E. Vom Steeg, Jr., of the General Electric Company gave an illustrated talk on "Applications of Modern Arc Welding."

W. B. Miller of the Pfaudler Company presented a paper on "Some Problems in Welding Steel with the Oxy-Acetylene Torch and the Electric Arc Process." A spirited discussion followed these two papers.

Mr. Tracey in closing the meeting gave a short talk outlining the benefits of membership in the Society. About 65 were in attendance.

Northern New York

The following officers were elected to serve for the coming year: Chairman, D. H. Deyoe; first vice-chairman, E. W. Bradford; second vice-chairman, W. L. Warner; secretary, V. J. Chapman; treasurer, J. C. Hoar. Directors (to serve for 2 years) J. C. Hoar, R. E. Wagner; (at large) R. D. Reed (to serve for 1 year).

San Francisco

The March meeting of the San Francisco Section was held on the 21st. At this meeting a paper was presented by James Weller, superintendent of the General Metals Supply Company, Oakland, Cal. Mr. Weller described the part that the acetylene torch is playing in dismantling the battleships that are being turned into scrap metal at the Union Construction Company's plant at Oakland. Some very interesting photographs of the work were shown.

The April meeting of the Section was held on the 18th in the Engineers' Club. C. R. Price, welding foreman of the Associated Oil Refinery at Avon, Cal., presented a paper dealing with "Welding Shop Experience in an Oil Refinery." Several other speakers presented their own experience in relation to shop practice.

Boston

The April meeting of the Boston Section was held on the 11th at the plant of the General Welding and Equipment Company. About 150 were present at this meeting. The feature of the meeting consisted of a demonstration of the largest automatic gas cutting machine ever constructed. Dr. A. Krebs gave an introductory talk about machine cutting. I. Allison presented a very interesting address on machine cutting in railroad shops. D. H. Miller of the Back Bay Welding Company gave a very interesting demonstration of aluminum welding.

The annual meeting of the Boston Section was held on May 9th at the General Electric Company, River

Works plant. Elaborate plans are being made to have this meeting the feature of the year.

Western New York

The second meeting of the Western New York Section was held in the Statler Hotel, Buffalo, N. Y. The speaker was Professor A. S. Kinsey, who presented a talk on "Liquid Oxygen the Wonder Worker." Actual demonstrations were made of the many uses of liquid oxygen.

Kansas City

The organization meeting of the Kansas City Section was held on April 1st. The temporary officers elected were given in the April issue of the Journal.

EMPLOYMENT SERVICE BULLETIN

Opportunities.—The Society is glad to learn of desirable opportunities from responsible sources, announcements of which will be published without charge in the Bulletin.

Services Available.—Under this heading brief announcements (not more than seventy-five words in length) will be published without charge to members. Announcements will not be repeated except upon request received after an interval of three months; during this period, names and records will remain in the office reference files.

Note.—Copy for publication in the BULLETIN should reach the Society's Office not later than the thirtieth of the month if publication in the following issue is desired. *ALL REPLIES should be Addressed to the Number Indicated in Each Case and Mailed to Society Headquarters.*

Positions Vacant

V-16. Manager wanted to take charge of Chicago office of manufacturer of electric welding equipment. Should have (1) intimate knowledge of electric welding, both arc and resistance, (2) experience in sale of electric welding machines, preferably, but not essentially, in the Chicago district. Please cover these points fully in your first letter.

V-17. Need a young salesman who understands the operation of welding and cutting apparatus, to assist us in selling our oxy-acetylene welding and cutting equipment in the eastern territory.

EMBLEM

All members of the Society are privileged to wear the Society emblem. Emblems may be obtained in two styles from the Secretary's office.

Price, gold-filled, 75c; 14-K. gold, $5.00.

Welding of Manganese Steel*

Preliminary Report of the Gas Welding Committee of the American Bureau of Welding

The work of the sub-committee on the Welding of Manganese Steel has been hindered by the untimely death of its chairman, Mr. Napolitan. Therefore the chairman of the Main Committee has taken upon himself to start the work by making some preliminary investigations of what happens during the welding of manganese steel, of how the actual operation may be best conducted, and of what the structural results of the welding are in both the base metal and weld. It will probably be well to discuss briefly what manganese steel is, what its properties are, and why it has those properties, and to do this intelligently, it will be necessary to say some things about steel in general.

Steel is essentially an alloy of iron and carbon. Soft steel, such as boiler plate, contains about 0.20 per cent carbon. Steels from which forgings are made which need strength, contains from 0.40 to 0.50 per cent carbon. Railroad rails contain about 0.70 per cent carbon. Tool steels contain from 0.80 to 1½ per cent carbon.

Commercial steel contains other elements besides carbon. Among these are manganese, silicon, phosphorus and sulphur. The amount of manganese in the steels above referred to will range from about 0.3 per cent to 0.7 per cent. We are not concerned at present with the amounts of the other elements, although they are always small. It may be said that it is desirable to keep the phosphorus and sulphur at as low a point as possible, because of their adverse influence on the quality of steel, and that silicon in the amount usually present has but little influence on the properties of the steel.

The influence of manganese on the strength of ordinary steel is direct and indirect. Direct in that it increases the tensile strength and yield point, and indirect in that it prevents the sulphur from being as harmful as it would be if no manganese were present; but, after all, the effects of manganese in ordinary steel are rather unimportant, carbon being the element which confers on steel its valuable properties.

The properties of ordinary carbon steel are greatly changed by heat treatments of various kinds. In the case of tool steel, which having the highest amount of carbon, most readily responds to heat treatment, it can be made soft and easily machinable, or glass hard, so that no tool except an emery wheel will touch it. As the carbon content decreases, the hardness with a given heat treatment also decreases, and with 0.20 per cent carbon steel even quenching from a very high temperature in ice water will not prevent the steel from being machined.

These changes in physical properties are revealed by micro-

*Prepared by Mr. S. W. Miller, Chairman Gas Welding Committee.

scopic examination, and it is found that they are entirely structural, that is, hardening produces no chemical change in the steel.

When steel is melted the liquid mass consists essentially of a solution of carbon in iron, just as water containing salt is a solution of salt water, and the freezing of liquid steel is entirely analogous to the freezing of water, except that the former occurs at a very much higher temperature than the latter. One other analogy may

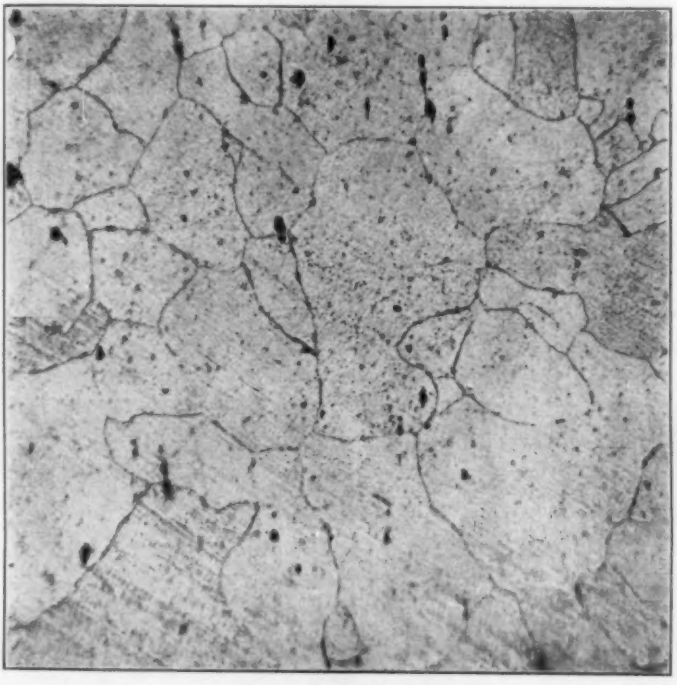


Fig. 1. Structure of very low carbon steel wire. The grains are usually irregular and have rounded boundaries. 200X.

be noted, which is that just as when the solution of salt and water freezes, the salt crystallizes out as such, leaving the ice as pure frozen water, so does liquid steel during its fall to room temperature reject the carbon, which crystallizes out as iron carbide, the main body of the steel being practically pure iron which has no solvent power for carbon at room temperature.

It has been found that during the freezing and cooling of steel certain changes in its structure take place which are readily observed under the microscope and which can be retained, to some extent at least, by quenching the steel at the different temperatures at which the changes occur. This quenching, however, even although very severe, will not entirely retain the changes in the steel because of their exceedingly fast occurrence during cooling, and also because of the comparative slowness of the cooling itself. Even a small piece of steel, say ½ in. square and ¼ in. thick, will remain

visibly red for several seconds when quenched in water, and during this time changes in structure can occur quite easily.

No matter what the rate of cooling, these changes or transformations must occur on the cooling down from the melted condition. The resulting structures are five in number and are called:

Austenite	Troostite	Pearlite.
Martensite	Sorbite	

The first four are named in honor of celebrated scientists and metallurgists. The last one is so called because of its iridescent appearance and similarity, when etched, to mother-of-pearl.

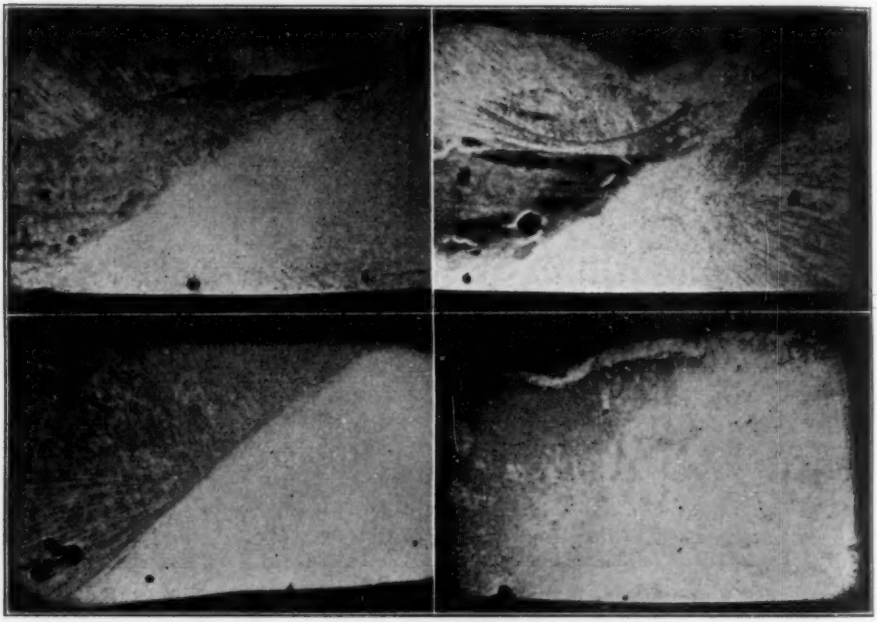


Fig. 2 (upper left). Weld A. As welded. Weld at left. Zones of irregular and uneven composition due to technique used. Weld not very clean. 1½ times.
Fig. 3 (upper right). Weld A quenched from 1150° C. Weld at left. Weld structure not entirely changed to austenite and zones not entirely removed. 1.5 x.
Fig. 4 (lower left). Weld B as welded. Structure in weld very uniform and sound. Weld at left. Base metal at right. 1½ times.
Fig. 5 (lower right). Weld B. Quenched from 1150° C. Weld at left. Coarse radial structure destroyed. Weld sound. 1½ times.

These changes occur in a steel of given carbon content at definite temperatures on both heating and cooling, and it is to be understood that they do not take place instantaneously and that time is required for them to occur completely. We are only concerned at present with two of them—austenite and martensite—because of their bearing on manganese steel.

It has been stated before that melted steel is a solution of carbon in iron. This solution is maintained as the steel solidifies, until a certain temperature is reached, which depends on the amount of carbon present. Above this temperature the steel is red hot al-

though solid, so that in this condition the solution is called a solid solution for obvious reasons. Below this temperature the carbon begins to crystallize out as iron carbide and the structure existing is called martensite, so that it is customary to speak of the temperature at which the change occurs, as a critical temperature or critical point, and for certain reasons it is called the upper critical

Fig. 6. Weld A. Quenched at 1050° C. View in weld. Even at this temperature some martensitic areas remain in this weld. Other areas of the peculiar martensitic areas seen at 850° C. and 950° C. remain. Evidently the general quality of this weld is not as good or as regular as that of weld B. 100X.

point, there being others at lower temperatures. It is also called the Ar_3 point, which defines it exactly.

Theoretically it should be possible, by quenching rapidly enough, to prevent the transformation from austenite to martensite and thus retain the austenitic structure at room temperature. Practically this is not possible because of the comparative slowness of the cooling and the great rapidity of the transformation. However, by using steel containing at least 1.5 per cent carbon, and by quenching it from a very high temperature in ice water, some of the austenite is retained, the rest of it having been transformed into martensite. Ordinarily, tool steels do not contain so much carbon and are not quenched so drastically. Therefore, the transformation from austenite is complete, and ordinary tool steel, quenched in the usual way, consists of martensite. Martensite is

very hard and brittle, and therefore quenched steel has the same properties. As we all know, these properties can be modified by tempering, or "drawing the temper," as it is frequently called. This operation causes the martensite to change through the other structures to that of annealed steel as the temperature is raised, with an increase in the softness and toughness proportionate to the increase in temperature.

Fig. 7. Weld A. Quenched at 1050° C. Area referred to in description of Fig. 6. 430X.

Now, if we can imagine that the world in which we live were continually at a temperature of about 2000 deg. F., ordinary carbon steel would be always in the austenitic condition and we would only be able to obtain the other structures, of which we have spoken, by artificially cooling them below atmospheric temperature. Looking at it another way, if we can add some element to steel which will lower its transformation point below room temperature, we can then maintain steel in the austenitic condition at that temperature. There are two elements that will do this, manganese and nickel.

Manganese steel was invented by Hadfield, who found that the most suitable composition was about 12 per cent of manganese and from 1 to 1½ per cent of carbon, the other elements being as in ordinary carbon steel, but in order to retain steel of this composition in the austenitic condition it must be quenched from a high

temperature. In the cast condition it is brittle and does not have the properties which it has in the quenched condition.

Properly treated, manganese steel is very ductile, can be forged and bent readily, but cannot be machined in any way except by grinding. It has the remarkable property of being exceedingly resistent to wear, the reason for which will be explained later.

Fig. 8. Weld B as welded with excess acetylene flame. View on line of weld, which is dark, and consists largely of martensite, as shown by the zigzag lines in the grains, a few of which appear in the grains of the base metal at the left. There is also some free carbide at grain boundaries in both weld and base metal. In parts of the weld the grains are columnar and one may cover the entire field. 100X.

The microstructure of manganese steel is shown in Fig. 8, and it should be noted that it consists of only one constituent, that is, the grains are all similar in appearance. In this respect, it is quite similar to ordinary pure iron, which is shown in Fig. 1, the main difference in the appearances being the angularity in the grains in the manganese steel and the absence of this in the grains of iron.

The softness, and at the same time the high wearing qualities of manganese steel, make a remarkable combination, and the explanation is interesting. It is easy to see that austenite must be a rather unstable constituent, as it must be held in its place, so to speak, by severe quenching, and it would seem clear that any disturbance of the condition would result in the natural transforma-

tion to martensite taking place, for instance, by slight heating or by hammering. It has been found that even such slight heating as is caused by using a hack saw, will change a very thin film of the austenite to martensite, which is exceedingly hard. Therefore, what happens in practice is that when the jaw of a rock crusher is abraded or hammered during service a film of martensite is formed

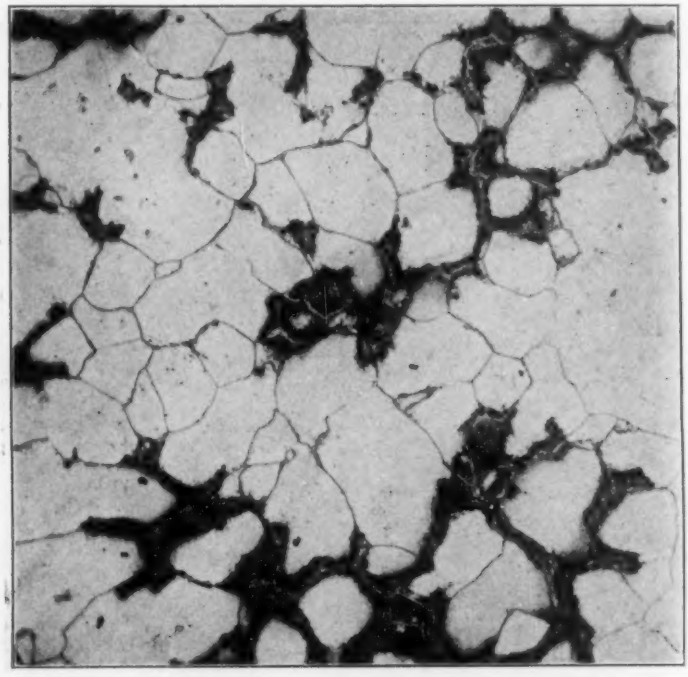


Fig. 9. Weld B. View of base metal away from weld. This appearance is the same in all the base metal, varying only in degree, the less the further from the weld. This condition is produced by welding heat, and shows that some of the austenite has been changed to martensite, the dark areas, in the center of which, at the grain boundaries, are thin films of carbide. The heat treating temperature has not been high enough to get the carbide back in solution. 100X.

at the outside of the manganese steel and this being hard resists wear. Even when it is ground away, another film forms, so that this film of hard martensite is what actually resists wear and not the austenite itself. This is illustrated in Fig. 14, which shows one edge of a saw cut made in a piece of manganese steel. It will be seen that there has been a trifling formation of martensite. While this martensite is not of exactly the same appearance as ordinary martensite, yet Howe has shown that this is what it must be.* The same general appearance is presented by a piece that has been deformed sufficiently.

The present tests were made on material about 1 in. thick and 4 in. wide, in the form of castings furnished through the kindness

*The Metallography of Steel and Cast Iron, chapter 26, page 460.

of the Taylor Wharton Iron & Steel Company, and the tests will be considered under the following subjects:

1. Technique of Welding.
2. Chemical Analysis.
3. Heat Treatment and Microstructure.

Fig. 10. Weld B. Quenched at 850° C. View on line of weld. Base metal above. This temperature too low to bring about complete solution of carbides, though some of the grains have become partly austenitic. Base metal dirty and has numerous intergranular cracks. 100X.

1. *Technique of Welding:*

The first weld was made in a piece 1 in. x 3 in., beveled to an included angle of the single V of 90 deg. The bevel was made by an oxyacetylene cutting torch and the piece was pickled in aqua regia to remove the cutting scale. The weld was made with a torch that consumes about 35 ft. of acetylene per hour, using a neutral flame. Under these conditions the welding was very difficult, because of the formation on the surface of large flakes of oxide, which could not be easily floated to the surface and therefore were mixed in with the weld metal. These particles were probably manganese oxide. This weld was so unsatisfactory in regard to time, consumption, difficulty of welding and poor results that it was discarded, no examination being made of it. The pieces were again beveled and this time welded with the same torch, using a neutral flame and an improvised flux. The performance was much superior

in every respect, but there was evidently not sufficient heat to keep the metal thoroughly melted.

The next piece welded was 1 in. x 4 in. and a torch using 50 cu. ft. of acetylene per hour was employed. At the beginning of the weld, an excess acetylene flame having a length of about three times that of the neutral flame was used, and the excess of acetylene

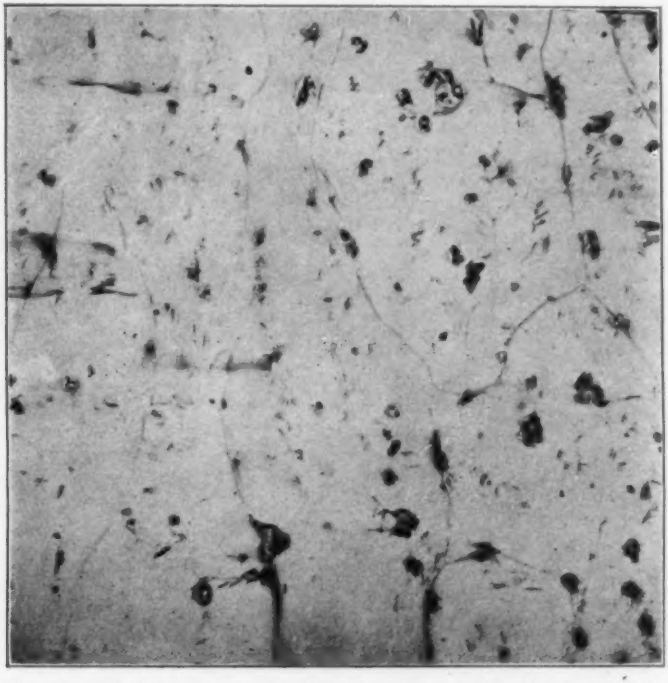


Fig. 11. Weld B. Quenched at 950° C. View in weld. Austenite predominant, but some martensite, the small angular lines indicating imperfect solution of carbides. Grains columnar and large with a few cracks along grain boundaries. Cracks near line of weld in base metal. 100X.

was gradually decreased until, at the end of the weld, the flame was neutral. In this case the same flux was used as before. The performance was better in every way than in the second weld, there being two differences—one a greater amount of heat and the other an excess acetylene flame. The change in the amount of acetylene seemed to make very little difference in the welding, so that the most of the advantage was from the larger amount of heat.

Chemical Analysis:

As in all other steel welding, the tendency is for the carbon to be burnt out during the operation, and therefore a small excess of acetylene is probably not injurious. The difficulty is that if too much be used, the melted metal will absorb carbon and thus become brittle. In order to check this action and also the loss of man-

ganese due to the same cause, two buttons about 3/8 in. thick and 1½ in. in diameter, were made from the same welding rod. One button was made by the use of flux with a neutral flame. In the other one no flux was used, but a slightly excess acetylene flame

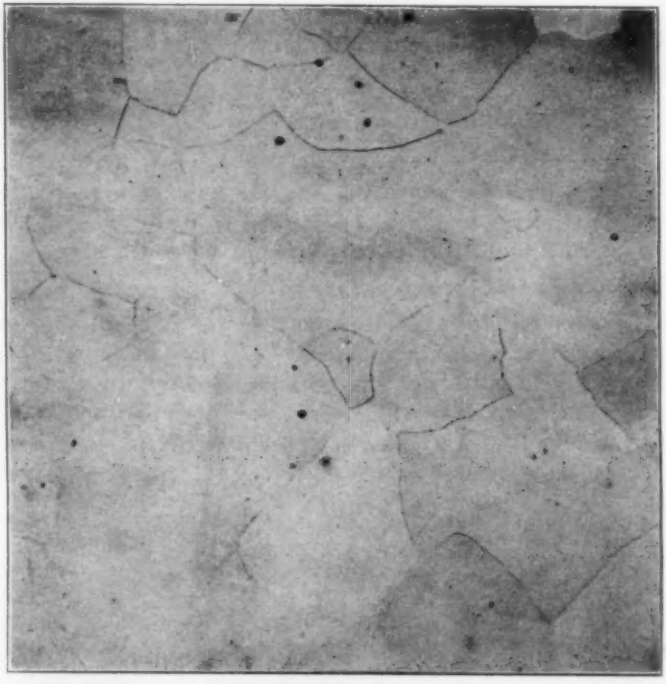


Fig. 12. Weld B. Quenched at 1050° C. View in weld. No trace of martensite, all the weld and base metal being austenite. Weld metal much cleaner than base metal. Grains in the weld have been coarsened by the heat treatment. There were a number of cracks parallel with and close to weld in base metal. 100X.

was employed. The analyses of the rod and buttons were as follows:

	Rod	Neutral Flame Flux used	Excess Acetylene No flux used
Carbon	1.18%	1.04%	1.22%
Manganese	12.23	11.28	12.23
Silicon	0.08	0.07	0.09

The welds themselves were also analyzed, with the following results:

	35 ft. acetylene per hour Flux used Neutral Flame	50 ft. acetylene per hour No flux used Excess Acetylene Flame
Carbon	1.12%	1.21%
Manganese	10.87	11.61
Silicon	0.06	0.08

It will be seen that there is some variation in the analyses of the buttons and of the welds. This is, however, no more than should be expected, because on account of the welding conditions it is impossible to keep conditions constant. These variations, however, are not sufficient to affect seriously the quality of the weld, particularly when the difficulty in sampling manganese steel for analysis is considered. The average quantities of the elements in the four welds were:

Carbon	1.15%
Manganese	11.50
Silicon	0.075

This certainly does not show any serious variation from the rod, and there is no reason to doubt that equally good results, or even better, can be obtained after experience.

Heat Treatment and Microsctructure:

The welds were cut into pieces about ¾ in. x 1 in. in cross section and 2 in. long, so as to include over half of the weld and enough of the base metal to note any changes in the structure due to the welding. The pieces from the first weld were marked "A" and those from the second weld "B." There were four pieces from the first weld and five from the second, which were treated, as shown in Table I:

Table I

First Weld A

A1—untreated.
A3—at 950 deg. C., held 30 minutes.
A4—at 950 deg. C., raised to 1050 deg. in 20 minutes.
A5—at 1050 deg. C., raised to 1150 deg. in 40 minutes.

Second Weld B

B1—untreated.
B2—at 850 deg. C., held 30 minutes.
B3—same as A3.
B4—same as A4.
B5—Same as A5.

There being only four pieces from weld A, there was no treatment given at 850 deg. C., as it was considered that at this low temperature no structural change would result. All of the pieces were quenched in water at room temperature, about 16 deg. C.

Macrophotographs of the untreated pieces and of those treated at the highest temperature, 1150 deg. C., are shown at a magnification of one and one-half times. From these can be seen, in the case of the first weld, wide variation due to the welding conditions, as evidenced by the layers of different carbon content and structure. In the second weld these are practically absent. Even the soaking for 40 min. at the high temperature has not removed these layers entirely from the first, while in the second, the appearance of the weld and that of the base metal is practically the same. In

both welds there was a gradual change in the appearance, due to the heat treatment, but not until the highest temperature was reached was there a complete obliteration of the original weld structure. It was not thought necessary to use many different temperatures and times of heat treatment, because in practice, the size of the piece has much to do with the rapidity with which the austenite solid solution is formed and in practical work this would

Fig. 13. Weld B. Quenched at 1150° C. View in weld. Structure all austenitic and large grained. Practically no difference between this and Fig. 1. 100X.

have to be determined to suit the conditions. It is evident, however, that the highest temperature used is about right.

The microphotographs* show some interesting things. In the untreated piece from the first weld there are a number of greyish spots, which under the microscope have the appearance of Fig. 7. Evidently the carbon content, or the heat treatment, or both, of these spots is different from the rest of the structure. Indeed it is possible that although extreme care was used in cutting the sections out, there may have been some change due to the heat from the emery wheel with which the work was done. It is doubtful, however, that this is the case, because none of these spots was found

*The section of weld A quenched at 1150° C. was austenitic except at the top, where some martensite was noticed.
Weld A as welded shows at 100X numerous laps and cracks in the weld. Structure generally similar to other as welded pieces, but a few areas of fine martensite.
Weld A quenched at 950° C. shows at 100X mostly large austenite grains with areas of martensite. No change of structure at this temperature.

in the second weld, which was treated in the same way. In this weld there were numerous inclusions which, of course, occupied the grain boundaries. While it is not possible to say positively what they are, it is believed that they are oxides. It is hardly possible that any other kind of dirt could exist to any such extent.

It should be also mentioned that some parts of the base metal

Fig. 14. Effect of hack saw cut on manganese steel. The austenite has been changed by the cold work to martensite along a very narrow zone. The many fine lines at the left of the edge indicate martensite. This has nothing to do with the welding of manganese steel, but explains the action of manganese steel under wear. 430X.

in both welds were shattered by numerous minute cracks and that weld A was no worse than the worst spots in the base metal, while weld B was much better, being practically as good as the best of the base metal, and much better than the average. It should also be said that the union between the weld metal and the base metal was excellent, although in a few places, especially in weld A, there were some cracks close to the weld metal and parallel with it. It is not possible to give the exact cause of these cracks. They may be due to shrinkage stresses. They may also be due to included dirt.

Complete notes are given with each microphotograph and a study of them seems to indicate that manganese steel can be successfully welded if proper precautions are taken. The principal difficulty will doubtless be cracks due either to included dirt or shrinkage stresses. The former can be overcome by careful welding and will tend to minimize the latter. If the base metal be unsound, it is

probable that the cracks will occur in it, and under such circumstances welding cannot be blamed. In any case better results will be obtained by preheating the base metal and this will be necessary with complicated castings or those of any great size. As a matter of principle, such castings should be preheated, welded and placed in the heat-treating furnace without being allowed to cool, and it should not be expected that welding without heat treating will produce satisfactory results. It is evident from a study of the microphotographs that any ordinary heat treatment, such as throwing water on a weld, will have practically no effect, because unless the piece be heated for a considerable time to a very high temperature, the austenitic solid solution cannot be formed, and unless it be formed and quenched drastically cold austenite will not result.

It also seems to be entirely possible to protect the melted metal from oxidation by suitable means so that the loss of the elements will not be so great as to prevent the production of satisfactory manganese steel in the weld.

Conclusions:

1. An oxyacetylene weld can be produced in manganese steel that is the equal in quality of the base metal.
2. The use of a flame having a slight excess of acetylene is not injurious and is probably of some assistance in making a sound weld.
3. It is essential that a powerful flame be used and that a large pool of melted metal be maintained.
4. The welding rod must not be rubbed in the weld, but must be left in the melted pool and the flame so applied as to melt the rod under the surface of the liquid metal. When the level of the pool is high enough it can be melted into the base metal by applying the heat around the edges till the weld and base metals flow together of their own accord.
5. Knowing that manganese steel is brittle when red hot, it is necessary to block up heavy pieces so they cannot be strained during welding or preheating.
6. No details of preheating practice being developed in the work so far, it can only be said that probably at least as much care is necessary as when welding cast iron, both in preheating, reheating and cooling.
7. It is shown that the same heat treatment is necessary for the weld as for the base metal, if the same structure is expected in both cases.
8. The tests show that for the conditions governing, a temperature of about 1050 deg. C. for about 30 min. was needed to produce austenite when water at 16 deg. C. is used for quenching.
9. It seems fair to conclude that throwing water on a weld will not produce the desired austenitic structure.
10. The use of a suitable flux will probably assist in making a sound weld, but the tests do not go far enough to determine the limits of efficiency in this direction.

Manufacturing All-Steel Automobile Bodies*

By J. W. Meadowcroft†

Our concern manufactures automobile bodies of *all steel* construction. This body is practically a one-piece body because of the large amount of welding used. The size and construction of the various bodies produced for the many automobile companies plays a very important part in the amount of welding used, but the average amount on each body is as follows:

1000 to 1100 spot welds
70 in. to 80 in. of gas welding, and
10 in. to 12 in. of metallic arc welding.

By using these three methods of welding in accordance with the construction of the bodies, long life is added to each body, and vibration, squeaks and rattles are eliminated.

Special electric welding machines are designed and constructed under certain standards (governed by the method of welding used), so that all bodies are held to correct dimensions while being spot welded. In assembling and welding our *all steel* bodies in these specially built electric welding machines, considerable time is saved in handling and welding the parts, as they are so assembled that enough welds are placed in same in a short period of time to provide the strength required. This allows us to produce large quantities of bodies on a small number of machines. Regardless of the method of welding used in connection with the assembly in these machines, the highest efficiency is procured, as no time is lost, because each operator does his particular part, finishing with his helper or helpers at a specified time period. Another feature of economy in production from these specially built welding machines is that the welding operators get the highest efficiency in assembling and welding the various parts of the bodies, due to the fact that the stampings or parts are interchangeable. Many welding operations are done on conveyors, regardless of the method, and although to the average engineer this seems impossible, it is done without any loss in the efficiency of the operation. Many other operations are done on the conveyors, but there is no interference with the various welding operations.

The acetylene gas welding operators are assigned to weld various sections of the body, and in each case the operator is a specialist on welding his particular part. This allows a higher standard to be maintained in the acetylene welding method and uniform welds are made on the various sections. Many parts of the interior of the body are also acetylene welded, thereby adding considerable strength to it.

Metallic arc welding is also used on the interior of the bodies

*Presented at the Annual Meeting American Welding Society, April, 1924.
†Supervisor of Welding, E. G. Budd Mfg. Co.

where no finish is required, and many parts are arc tacked together without the aid of clamps, jigs, etc., and the pieces are still kept in alignment. This method is also used on sections of the doors where a quick weld must be made to prevent warping or buckling of the various sheets of light-gage metal, thus eliminating a considerable amount of finishing.

In the design of the bodies the utmost care and thought is taken to lay out the various sections and to arrange the stampings that are welded, in order to facilitate their ready assembly in the specially designed jigs and fixtures. The assembled bodies are light in weight, strong, free from defective joints, and present an exterior surface which is free from pits, blow holes or indentations. Any one of these imperfections in the metal would act as a reservoir for japan, which, when applied and heated to 450 deg. F. in baking ovens, would produce a blow or blister. The surface is therefore kept free from any depressions or cavities in which more than the standard thickness of enamel can flow.

Many of the stampings have different shapes, making it necessary to weld additional pieces to same, and all parts are clamped together in such a manner as to assure good contact in making welds. This is very essential in spot welding, as it is necessary to spot weld the various sections of the bodies together so that all indentations in the metal are eliminated. On some of the interior parts, which are not exposed, the indentations receive no consideration, as no finishing is done on these parts, but in all cases where welding is used, whether it be interior or exterior, whether parts are perfectly flat or shaped, it is absolutely essential to make the proper allowance for contraction at point of weld, so that the bodies are produced in their proper shape and held to their proper dimensions. By making the proper allowance for contraction, the bodies are held uniform. This makes it possible for fenders, and other accessories made correct to shape, to be interchangeable.

In the process of manufacture of bodies at our plant, more light sheet steel is used and more welding is done than in the manufacture of any other commodity made from sheet metal. All methods of welding, thermit excepted, are used, and no matter what method is applied it is applied from an economical as well as a productive standpoint. One day's production in our press shop amounts to 600,000 strokes, and more difficult steel stampings are made here than in any one plant in the country. The steel consumed in one day's production amounts to approximately 1,000,000 lb. In our daily production, 18,000,000 spot welds are made on 360 standard electric spot welding machines and 150 special machines. The daily shipment of "Budd All Steel Bodies" amounts to 80 carloads, containing approximately 2200 complete bodies assembled and 1750 complete bodies unassembled.

The application of the various methods of welding would be of very little value from an economical standpoint if they required

more finishing. In speaking of finish, we come to one of the most vital items, as only three coats of paint are applied to bodies, making it necessary for the finishing to be of high class order, as imperfections of any kind would magnify many times after the final coat of enamel is baked on at 450 deg. F. All steel bodies are painted in a time period of approximately one day, whereas composite bodies are painted in a time period of from 14 to 21 days and are given nine to fourteen coats of paint. A cheaper grade of metal can be used on composite bodies, due to the many coats of paint and filler which is used, but the lasting quality of the paint on all steel bodies is far superior to that of composite jobs. The reason for this is that composite bodies are made from wood and steel, which, of course, cannot have paint baked on at such a high degree of heat.

Another very important feature in favor of an all-steel body is its tremendous safety value. Although all the automobile manufacturers are not using *All Steel*, it is only a matter of time when all bodies will be of all-steel welded construction, as bodies of this nature will dent or bend in collision, causing less serious results to both the occupants and the car. The car can be restraightened and used again, causing practically little or no loss to the owner. When a composite body is in a collision, it telescopes, causing serious injury to the occupant, and practically a total loss to the owner of the car, as no material can be saved.

Hints for Welding an Aluminum Casting

BY E. E. THUM

A paper recently appearing in the columns of the trade press described in general terms welding of aluminum with the oxy-acetylene flame. Since aluminum welding is to most operators a rather "tricky" job, even though done with the oxy-acetylene flame, it is perhaps in order to give a few details of the actual practice.

It would be impossible in brief compass to give all the information for welding any kind of aluminum sheet or aluminum casting, because there are several alloys marketed extensively at the present time, each one of which the expert welder knows will require certain small changes in his practice to give him the best job.

Merely to enumerate them, we have, first, sheet aluminum, ordinarily used in kitchen utensils, tanks, automobile bodies, and containers for chemical and food industries. It is high grade, commercially pure aluminum, hot rolled to the required thickness.

Second, a family of aluminum alloys containing small amounts of copper or nickel and magnesium have been marketed under the trade names of "Duralumin," "17S" and "Y-Alloy." These become much harder than pure aluminum and very strong. After being rolled into strips or sections and given correct heat treatment and ageing, they are formed into structural sections and used to a considerable extent in aircraft and dirigibles.

Most aluminum castings on the market, however, are made of an alloy called "No. 12 Alloy," consisting substantially of 92 per cent commercial ingot aluminum and 8 per cent copper. During the last few years, however, a new series of casting alloys have come rapidly to the front. These alloys are of commercial aluminum ingot with 8 to 15 metallic silicon, melted with a special flux

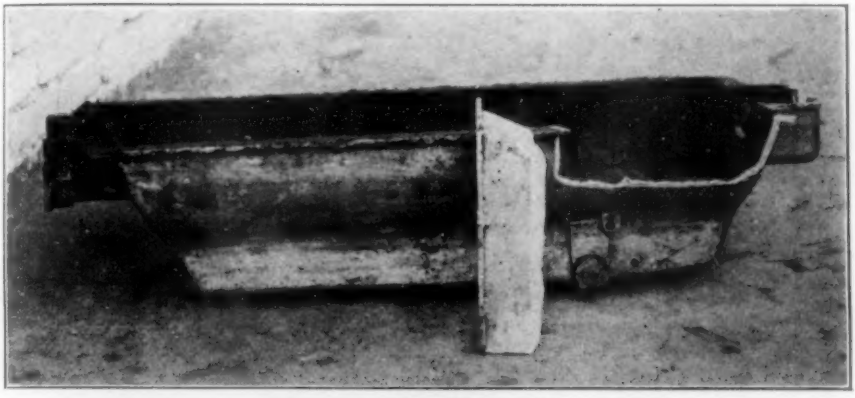


Fig. 1. The Broken Casting

to enhance their physical properties. Such alloys are variously named, such as "Alpax," "Silumin" and "Modified Castings."

Yet another class of castings is known as aluminum bronze. These are really brasses (that is to say, alloys of copper and zinc), to which a little aluminum has been added to remove oxides and improve the physical characteristics. "Aluminum bronze" is perhaps a misnomer—as, in the first place, they are not true bronzes, and in the second place they contain but very little aluminum. Aluminum bronze is rather difficult to cast.

It must be seen that extended space would be needed to discuss in detail the proper practice in making welded joints in these varied alloys. Furthermore, the probability that some of them would ever reach the repair shop is rather remote—some of them (such as "Y-alloy") are very specialized products and their preparation is in the hands of specialized workmen. Consequently the following remarks will refer almost exclusively to the casting alloy containing about 8 per cent copper, known as No. 12 alloy, and from which are made most of the aluminum castings which would be likely to find their way in the repair shop today.

When a broken aluminum casting is to be welded, the first thing to do is to clean it carefully, removing every trace of oil, grease and dirt. It is not necessary to tool the crack or cut out a vee. If a piece is broken out it should be held in correct position by light iron bars and appropriate clamps. These clamps should not be drawn up tight—just snug. Braces and clamps should be attached so as to avoid straining any portions of the casting—especially the

thin walls—when hot metal is very weak and will crumple under slight strains. Then place the casting in such position that the crack to be welded is on a horizontal surface, and build a furnace about the casting, using firebrick laid snugly without mortar. A very moderate amount of charcoal should be placed around the lower corners of the furnace and set on fire, covering the furnace top at the same time with a sheet of asbestos paper.

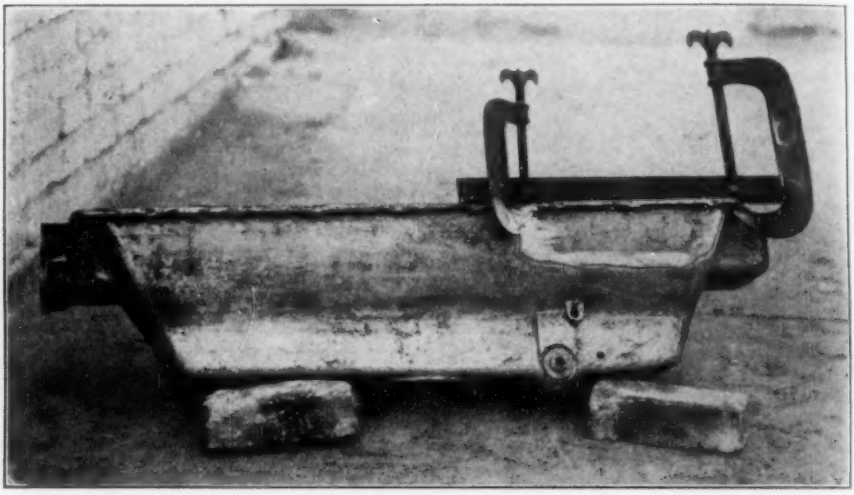


Fig. 2. Casting Lined Up for Welding

It is extremely important that the fire be kept under close control and that the casting be heated very slowly and only to a medium temperature. When spit balls up and dances on the hot metal, the heat is right for welding. Another good way to test for correct temperature is to see if it will melt soft solder, or char sawdust. Aluminum in this condition is extremely tender and, therefore, must be handled with greatest care.

As soon as the casting is properly preheated, light the blowpipe, and starting at the middle of the break, heat the metal for a distance of about 2 in. Use a flame containing a small excess of acetylene. Hold the tip of the blowpipe at least 2 in. from the casting at all times and move it freely so that no spot becomes very hot. The metal will melt before you know it!

In a few seconds the metal will become soft enough so that a vee reaching to the bottom of the crack can be scraped out with a little chisel or paddle made from an iron welding rod. When about 2 in. of the crack has been prepared in this manner, add aluminum welding rod to the space by holding the rod in the flame near the metal. Contrary to welding practice on steel or cast iron, aluminum must be flowed into the weld by the flame, because the heat in the puddled metal will not melt aluminum. When a few drops are melted off the welding rod, work it around and into place with a

rubbing motion of the rod. Be sure to get this new liquid metal to the bottom of the vee, all the time playing the torch about freely, but always with the tip at least 2 in. from the metal.

Then, when this portion of the prepared vee has been filled with the welding rod, continue playing the flame over it, keeping it in a "mushy" condition (very much like the lead in the wiped joint

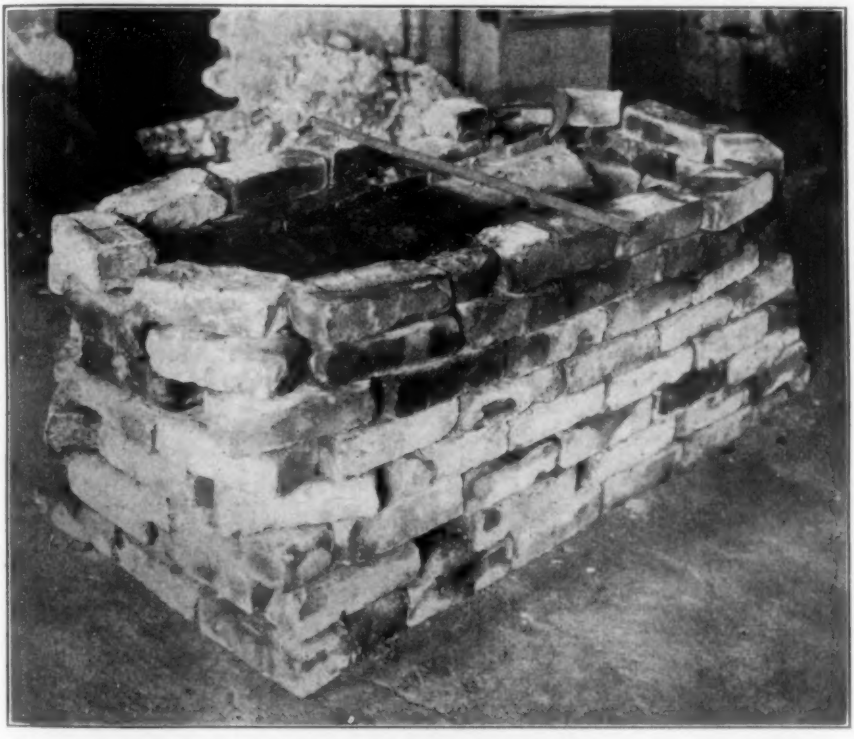


Fig. 3. The Weld Completed

made by plumbers), and smooth it down with a small paddle made of heavy iron wire.

This series of operations should then be repeated, being careful to vee the notch back into the welded portion each time. Continue by 2-in. steps until the weld is finished, moving the castings very carefully from time to time when necessary to keep the weld horizontal. Do not remove clamps or braces unless it is absolutely necessary, and then only with extreme caution, else you will have a new break to repair.

When the weld is finished, anneal the casting by adding four or five handfuls of charcoal, being sure to cover the furnace top with asbestos paper. Let the fire burn out slowly and cool the casting in the furnace. When removed it may be touched up with a file if it is important to have a smooth surface.

In following such general directions the welder will, of course,

discover in individual cases many points where special caution is necessary. Therefore, it is a first principle before an important job is undertaken to get a broken aluminum casting, such as a crankcase, from a junk dealer and make several experimental welds on it. After making a weld of this sort, take a hack saw and cut a strip out of the case so the welded seam crosses the center. Grip one end of this test piece on a vise and bend it back and forth until the piece breaks. Throw the maximum bend in the weld so that when it breaks open you can discover for yourself whether the welded metal is sound, whether penetration reached to the bottom of the break, and whether the added metal is closely knit into the original plate.

Such test pieces are extremely valuable in giving the welder information upon the quality of the work he is doing, and should be made periodically on all classes of welding, be the metal steel, cast iron or aluminum.

Compressed-Dissolved Acetylene*

BY M. A. DANTZLER†

Compressed-dissolved acetylene is acetylene gas which has been compressed and dissolved into specially designed portable cylinders, which may be "tapped" at the convenience of the consumer at varying distances from the source of manufacture.

Most everyone is familiar with calcium carbide, or "Carbide" as it is more generally called, which is the source or mother of acetylene supply; however, even recently I came across several men in different sections of this country who wanted to know where carbide was "mined." Calcium carbide is a product of the modern electric furnace, wherein coke and limestone are properly fused, and this changed material is known as calcium carbide.

Acetylene, before being compressed and dissolved, is manufactured in the usual manner by dissolving calcium carbide in water, with the exception that it is generated in larger quantities than is the case where used for general welding, direct from generators. The gas is given off due to the chemical reaction of water combining with calcium carbide; lime oxide being the residue.

After generation, the acetylene gas is stored in a gas holder, built for this purpose, usually of several thousand cubic feet capacity. Before it is compressed and while under low pressure, it is conducted from this storage supply in pipes to the purifying room and thence to the compressor. The chief impurities in acetylene are sulphur, phosphorous, and ammonia compounds.

These impurities exist in relatively small proportions, but they must be "fixed" or held in the purifying material, allowing only

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*Paper read before the Chicago Section, A. W. S., April 4, 1924.

†Gas Tank Recharging Co., Milwaukee, Wis.

pure acetylene to pass through the compressor, and on into the cylinders or drums.

It is not customary among manufacturers of acetylene generators in America to equip their acetylene generators with chemical purifiers; however, most of the foreign manufacturers do. Dissolved acetylene is the purest acetylene possible to use, as when properly purified and dried it will analyze 99.64 per cent C_2 H_2. A large number of cylinders are attached to the recharging manifold; as an example a compressor which will deliver approximately 3000 cu. ft. per hour, running at slow speed, say 50 r.p.m., would discharge this gas into from 50 to 100 acetylene cylinders connected on the manifold. The larger number is preferable.

When the gas leaves the compressor it is under pressure and is pumped through double extra heavy wrought iron pipe to the manifolds, where are connected the empty acetylene cylinders ready to receive the gas. In the high pressure pipe line must be located proper oil traps or separators to remove the oil and any moisture after the gas has left the compressor. Compressors which force the gas into the cylinders are operated at a relatively slow rate of speed so as to keep the gas as cool as is possible. The temperature should not rise above 120 deg. F., in summer weather, at the point of discharge of the compressor. In very warm weather it is advisable to "cold-water" spray the cylinders being charged on the manifold, and the nearer the temperature can be kept to 40 deg. F. when charging, the nearer the maximum amount of gas can be stored in the cylinders.

Owing to I. C. C. regulations which do not permit more than 250 lb. pressure at 70 deg. F. in any acetylene cylinder, regardless of cubic foot capacity, the cylinders must receive at least two "shots" of gas; for instance, cylinders receiving the first "shot" in the morning, should be allowed to remain on the racks until the following morning, when they will receive the second or last "shot."

This process of filling cylinders is somewhat different from that of filling oxygen and hydrogen cylinders. In the latter case the cylinders may be filled very rapidly and only a few at a time; whereas a large number of acetylene cylinders must be on hand before they can be refilled, and a much longer time is required in pumping the gas.

After the cylinders have received the second "shot" of acetylene, which brings them up to the maximum amount of pressure permitted at 70 deg. F., they are removed from the charging manifolds and the cylinder weighed to determine the number of cubic feet of gas contained therein. In America and Canada, acetylene gas is computed at the rate of 14½ cu. ft. per lb. of acetylene. Of course, the cylinders are weighed before they are placed on the manifolds to be refilled, and this information is recorded on the cylinder tag which is attached to each cylinder, a duplicate part of which is later detached and retained by the manufacturer.

Acetylene cylinders, while they do not have to withstand the pressure that oxygen and hydrogen cylinders do, are nevertheless expensive containers for the amount of salable material they contain. The larger size cylinders, which are approximately 12 in. by 36 in., retail for $70 each, but, of course, the manufacturers who buy them in large quantities are able to receive the benefit of a somewhat cheaper cost price; however, the fact remains that acetylene cylinders are very expensive containers; few, if any, other widely used commercial commodities require so expensive a container.

The seamless drawn steel shell of acetylene cylinders is not the most expensive part; the porous filler and solvent (C. P. acetone) contained in the cylinder are more costly. The maintenance of acetylene cylinders is considerably greater than that of oxygen cylinders, as some of the acetone solvent is drawn off with the discharge of gas every time the cylinder is used; particularly is this true when large welding tips are being used, and the acetone must be replenished when the cylinders are returned and before they are put on the manifold for refilling. The acetone content of acetylene cylinders is equal to 40 per cent of the porosity of the filling material. Acetone, during the past year has been as high as 28 cents per pound in carload lots, so you can readily see that it is not an inexpensive item. Of course, upkeep of acetylene cylinders such as valve repairs and painting of cylinders, are about the same for acetylene as for oxygen.

The oxygen manufacturers have one advantage over the acetylene manufacturers in that there is no characteristic odor connected with the escape of oxygen or hydrogen through a leaky valve. If there is a *slight* leak in the acetylene valve, or in the operator's connections, it is very noticeable by its odor, and it is really surprising how a small amount of acetylene will cause the purchaser to believe he is losing all of his gas.

From the foregoing cost of the cylinders, you will readily appreciate that the acetylene manufacturer carries a considerable portion of his invested capital in these portable containers, but if you happened to drop in at his plant you would wonder where all the thousands of cylinders were, as only a few hundred are to be seen in the plant at any time.

In the State of Wisconsin, the Wisconsin Industrial Commission have issued a set of rules and instructions governing the compressing of acetylene. These rules are very stringent and not only do they pertain to the buildings and their locations, but even to the machinery. They specifically state the distance that a charging building may be located from other adjoining property, which practically results in acetylene compressing plants being located outside of city limits.

I think that some of the operations in compressed acetylene plants, which I have not referred to, would be of more interest

than those which I have mentioned, but unfortunately I am not at liberty to go into these details.

In conclusion I wish to say that those of you who are contemplating going into the compressed acetylene business should realize that considerable capital is necessarily involved to enable one to get properly started and meet the prevailing competition; also please remember that the dissolved acetylene business is confined to a comparatively small area of operation adjacent the plant location.

Freight rates on the heavy containers prohibit long shipments of acetylene gas, and prompt delivery service is what is required by acetylene users. However, the use of dissolved acetylene is still on the increase. Approximately 350,000,000 cu. ft. of compressed acetylene was used during 1923. This was a substantial increase over 1922, and the indications are for a greater increase during 1924.

Fluxes and Slags in Oxy-Acetylene Welding*

By C. Coulson-Smith, M.Sc.

The actions which take place in the oxy-acetylene flame are as follows:

Two molecules of acetylene require for complete combustion five molecules of oxygen and this reaction takes place in two stages:

(1) One molecule of acetylene unites with one molecule of oxygen, forming one molecule of hydrogen and two molecules of carbon monoxide.

(2) This carbon monoxide on combustion yields carbon dioxide, and the hydrogen on combustion yields water vapor.

The Welding of Mild Steel

Here we should be dealing with a material which has a melting-point of approximately 1500 deg. C., and being free from sulphur and phosphorus, there only remains the avoidance of oxidation of the iron itself, which can be brought about by

(1) Excess oxygen in the flame itself,

(2) Atmospheric oxygen,

and (3) The water vapor obtained from the products of combustion of the acetylene,

the latter taking place mainly in the outer envelope of the flame is almost a negligible cause.

With a perfectly regulated blowpipe, the oxide formation in mild steel welding is very slight, and in consequence fluxes are not generally used, although they are marketed. The point as to whether molten iron actually is or is not capable of dissolving up to 1 per

*A contribution to a general discussion on "Fluxes and Slags in Metal Melting and Working" held by the Faraday Society and the Institute of Metals with the cooperation of the British Non-Ferrous Metals Research Association and the Institute of British Foundrymen, on Monday, April 28, 1924.

cent of the oxide is a matter of considerable variance of opinion, yet results obtained in welding a good quality of mild steel without the use of a flux show on examination of the weld very small oxide inclusions, and mechanically the welds are not found to be weakened to any appreciable extent, as the oxide formed is less dense than the metal and rises to the surface, forming a slag which is easily removed.

The composition of the filling in material must, of course, be as near as possible to that of the material to be welded. It must have a low carbon content (approximately 0.15 per cent) in order to have as little as possible of this element to be oxidized to carbon dioxide, and so cause consequent sparking under the heat of the flame; and the sulphur and phosphorus content must have a maximum of 0.05 per cent, as these not only cause ebullition on welding, but remain in the weld, causing brittleness.

The Welding of Cast Iron

An average grey iron analysis is as follows:

Fe	92.3	per cent
Graphite C	2.99	"
Combined C	.37	"
Si	2.52	"
P	1.08	"
S	.02	"
Mn	.72	"

In cast iron, the oxidation of the iron itself and of the other constituents, renders the welding difficult, and a process of puddling the molten metal is generally resorted to. The point of interest to us, however, is that oxidation occurs, a slag having a higher melting-point than that of the metal itself is formed, and, being more dense, sinks through the molten metal and may be incorporated in the weld if not removed by some chemical means such as the flux provides. The actual influence which the oxide exerts is to increase the surface tension. The surface tension of the metal is low, and the object of using the flux is to overcome the excess set up by the oxide formation, so as to bring the oxide to the surface. The constituents of the flux either dissolve this substance or float it off along the line of weld. All care should be taken to avoid excessive oxidation, but no matter how great the precaution taken it cannot be totally avoided. In foundry practice, limestone is used, the object of this in the blast furnace production of iron being to obtain a less siliceous slag, low in iron content and more fusible. The limestone adds lime to the free silica and ferrous silicate constituents, thereby increasing the fluidity and lowering the temperature of slag fusion. If too much limestone is added the slag becomes refractory and the metal loses silicon, iron, and manganese, and a white iron is formed. Now similar results are obtained in welding, provided an efficient flux is not used. The

fluxes used are many, but it must be remembered that the melting-point of all fluxes must be lower than the melting point of the metal to be welded. The most general constituents of the fluxes for cast iron are mixtures of sodium borate, sodium carbonate, sodium bicarbonate and silica; as reducing agents one sometimes finds incorporated a trace of aluminum. The reactions which take place are, I think, as follows:

The silica reacts with the sodium carbonate, forming sodium silicate. This in turn reacts with the sodium borate, forming a borosilicate and free borax which, being a solvent for oxide iron, forms ferrous silicate. When this molten ferrous silicate is exposed to the air, partial oxidation takes place and crystals of Fe_3O_4 are formed, and such a slag in contact with the impure metal gives up its excess of oxygen (from the Fe_3O_4) to the oxidizable elements present and again becomes reduced to ferrous oxide. In the welding of cast iron, ferro-silicon rods are used as filling material, which contain approximately 3 to 3.5 per cent silicon, and this replaces or can replace any loss of silicon. Titanium as an ingredient is also made use of, especially on account of its combining property with nitrogen.

The Welding of Non-Ferrous Metals

Copper—This metal is capable of forming two oxides, cuprous oxide and cupric oxide, and care must be taken to prevent this formation as much as possible. This being very difficult, the use of fluxes are resorted to, which will dissolve the oxide formed.

The fluxes used are generally either sodium borate or a mixture of sodium borate (anhydrous) and boric acid, sometimes with the addition of sodium chloride to lower the melting point of the flux. The following reactions seem to take place: The sodium borate and the boric acid at high temperature yield boric anhydride, a vitreous mass, soluble in water, forming boric acid. This boric anhydride combines with the oxide of copper, forming copper borate. The melting point of this borate is fairly high and the addition of the sodium chloride has been found to bring the melting point lower than that of the copper itself. As a deoxidizer, small quantities of phosphorus are sometimes included in the flux; when this is done, careful addition should always be made, the amount added being arrived at from the knowledge of oxide capable of being formed. When so added, phosphorus cannot but exert a good effect, and it does so by diffusing throughout the molten metal and destroying any dissolved oxide. The slag formed is very fluid and rises to the surface of the metal, forming a protective coating. Silver has also been used to the extent of 1 per cent.

Brass—In this alloy we have the following phenomena: (i) Oxidation; (ii) volatilization of the zinc; (iii) absorption of gases. Oxides of copper may be formed, also loss of zinc by burning to the oxide, and also loss of zinc due to the reduction of the oxide of copper by the zinc itself. As a rule, a flux of similar composition

to that of the copper flux is used. The difficulty in reducing the loss of zinc due to oxidation is due to the fact that the melting point of brass is about 930 deg. C., while zinc volatilizes at 940 deg. C. Traces of aluminum are often introduced into the flux, or alloyed with the filling in material. This suffices to serve a two-fold effect, namely, to prevent loss of zinc by volatilization and also by the oxidation of the zinc, and to act as a deoxidizer, and the alumina formed protects the metal from further oxidation and dissolving of gases. The amount of aluminum to be added is obtained from the fact that the addition of 1 per cent of aluminum is equivalent to 3.5 per cent zinc, or, in other words, aluminum greatly raises the zinc equivalent.

In the melting of gun metal or admiralty bronze, the founder often uses sand as a flux, but obviously this will not prevent oxidation and may even increase the melting loss by fusing with the oxides of copper and zinc to form infusible slags. Borax is also used; this forms a protective coating and actually assists in fluxing off dross which would otherwise collect as an infusible mass on the surface of the metal or enter into the metal itself. Powdered charcoal is good and helps to preserve a reducing atmosphere, and assists in reducing to the metallic condition small proportions of copper and zinc oxide which may have been formed. Sodium chloride is also used, but with zinc it gives a volatile chloride which is both dangerous and a further source of loss. In acetylene welding similar conditions are met with, and in choosing a flux the one most capable of overcoming these disadvantages is to be preferred; that is, one containing a mixture of boric acid, sodium borate and sodium chloride.

Bronze—The essential constituents of this alloy are copper and tin, and it may contain zinc, lead, manganese, iron, silicon, and phosphorus, as impurities. In welding this material, both ebullition and oxidation occur. In the bronze, the tin in the alloy acts as a deoxidizer and is eliminated as a slag. Examination of welds show that no trace of oxidation is shown when a flux capable of dissolving and eliminating the stannic oxide is used. The welding rod used should always contain phosphorus to prevent loss of tin by volatilization; fluxes or filling wire with aluminum is also beneficial. The components of a bronze flux are, as a rule, similar to those for copper and brass, with the addition of a little finely divided aluminum.

Aluminum—The main difficulty experienced in the welding of aluminum is due to the rapid formation of aluminum oxide on the surface of the metal, and since the melting point of aluminum is 657.8 deg. C., and that of its oxide 3000 deg. C., it is possible to melt the aluminum without melting the oxide, and, in endeavoring to melt the oxide, overheating occurs; if, on the other hand, overheating is avoided, inclusions of unmelted oxide results. To overcome this difficulty the use of fluxes is resorted to. The oxide of

aluminum is very difficult to disperse, and the function of this flux is to dissolve and deoxidize the layer of aluminum oxide adjacent to the joint to be welded. Generally, one would desire to use mixtures of the alkali metal halides and alkaline earths, together with a fluoride, which melts at a lower point than the aluminum, is not readily volatile, and does not contain any metal which would be reduced to the metallic state by the aluminum. However, no fluoride has all these properties, and hence the addition of alkalies and alkaline earths. Cryolite, a double fluoride of aluminum and sodium, has been tried, but not with any success as a sole constituent of a flux for aluminum. This certainly, on fusion, is capable of dissolving aluminum oxide, but the melting point of cryolite itself is 957 deg. C., which is altogether too high.

An example of what I consider a good flux for aluminum, with a melting point 600 deg. C., is one containing a mixture of lithium chloride, potassium chloride, potassium bisulphate and potassium fluoride. The reactions which take place in fluxing are, I think, as follows:

The potassium fluoride reacts with the potassium hydrogen sulphate, forming hydrofluoric acid, and this immediately acts on the aluminum oxide, forming aluminum fluoride, which is free to combine with the excess of potassium fluoride existing in the flux, to form potassium aluminum fluoride, and this is capable of dissolving a further quantity of aluminum oxide. The lithium chloride and potassium chloride added, serve the purpose of lowering the fusion point of the mixture.

Another aspect is that the potassium bisulphate may act partially alone, for on heating this salt to a temperature higher than its melting point it forms potassium pyrosulphate, and on further heating breaks up into potassium sulphate and sulphur trioxide. As this decomposition takes place at about 600 deg. C., it can be understood how the bisulphate will decompose substances like cryolite and calcium fluoride at a lower temperature than that required to fuse the mineral or salt itself.

Now aluminium melts very slowly, due to its high specific and latent heat and, when castings are to be welded and sand may be present, they should be freed from this, as the silica is reduced to silicon which weakens the alloy. A flux often used for this class of work is composed of potassium chloride and fluorspar; this will on fusion dissolve the silicon and prevent combination with the aluminum.

Now, for an aluminum flux, one must be obtained which has a lower melting point than that of aluminum itself, and in all the aforementioned examples of fluxes, the melting points can be arrived at, not only of the completed flux, but of their separate constituents, by taking a quantity of the salts or flux, and heating in a graphite crucible, in a Fletcher Russell coal gas air furnace, using a platinum, platinum rhodium thermo couple connected to a milli

voltmeter recorder and noting the temperature of fusion and arrest points on solidification.

Taking an aluminum flux containing potassium chloride, sodium chloride, lithium chloride and a fluoride, the solidification point of the binary series KCl-NaCl was determined, and by plotting freezing points as functions of composition, the liquidus curve was obtained. No arrest point and therefore no cutectic point was observed. A similar result was obtained with the sodium chloride—lithium chloride series. But two arrest points and therefore two cutectic points with the potassium chloride—lithium chloride series were noted. Further investigations on this are contemplated.

The lowest melting point obtained in the sodium chloride—potassium chloride series was 660 deg. C. This was insufficiently low. Search for a chloride of a still lower melting point shows two possibilities, the use of lithium chloride and calcium chloride. Both these in suitable proportions, with either or both of the above chlorides yield mixtures of suitable melting points, i.e., lower than 658.7 deg. C. Choice therefore seems to lie in their fluxing properties; all other conditions being constant, lithium chloride has proved the most active.

Referring again to the property of a flux to decrease surface tension, there appears to be an interesting exception to this, in the case of aluminum and its flux. Undoubtedly the surface tension of this metal in the presence of a flux is greater than that of the metal covered with oxide. This is, in my opinion, due to the thick film of oxide forming a semi-rigid structure, so that the resultant force of the surface tension is less than if the oxide were absent. The flux dissolves this semi-rigid structure of oxide thereby causing greater fluidity of the metal (here lies the value of the flux), and the exertion of the true surface tension.

Soldering of Aluminium.—In soldering aluminium, using the metal itself or its alloys, the joints made do not maintain their strength for any length of time. The difficulties to be overcome are due to:

(1) The peculiar resistance to interfusibility, due to the formation of a film of oxide at soldering temperature preventing interunion with the aluminium beneath it, and in consequence the solder does not firmly adhere to the surfaces to be united.

(2) The thermal conductivity of the aluminium.

(3) The high position of aluminium in the electrochemical series.

(4) Few metals will "tin" or alloy with aluminium at low temperature.

(5) Strong electrolytic action which occurs between aluminium and alloying metals in the presence of water.

(6) Aluminium readily goes into solution at the temperature of boiling water, and the salts formed accelerate electrolysis.

The alloys used are generally zinc-tin mixtures, with or without aluminium, and copper or phosphorus. In the latter, the phos-

phorus is added in the form of phosphor tin or copper, and is intended to act as a reducing agent of the aluminium oxide present after the cleaning and heating, and so obtain a good "tinning." Some solders are free from phosphorus but contain a high tin content. These give joints of a low tensile strength and short life, but are more or less free from electrolytic action. However, the greater part of the solders that I have tested—their names are legion—are alloys of tin and zinc. They are good in that the joints stand mechanical tests well, and the alloys are easily worked and require no flux, but boiling water destroys the joint rapidly, and even on exposure to air they rapidly disintegrate.

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Fluxing Problems in Welding of Mild Steel with the Metallic Arc*

By H. Ogden, B.A., B.Sc.

The first men to apply the electric arc to effect the union of two pieces of steel by interfusion, Bernados[1] with the carbon arc and Slavianof[1] with iron wire as the electrode, did so without the use of flux. In all probability the first weld ever accomplished in iron was made ages ago without flux, for it is well known that some wrought irons, by virtue of their 1½ per cent of low fusible cinder, flux themselves. With the purer metal, steel, it is usual in forge welding to use an added flux, usually sand or borate, the function of which is to protect the hot metal from contamination by the fuel and oxygen of the air, and to form with the scale a low fusible slag, which is squeezed from between the welding faces by external pressure. It is suggested that this use of flux in forge welding first turned the attention of such pioneers of arc welding as Pommee[1] of Hamburg, to the possibilities of the similar use of flux in arc welding. It is known that the first attempts at fluxing were made by dusting the weld with the smith's flux during its formation under the arc, but this method was quickly replaced by the automatic method of applying the flux as a coating on the welding wire. In arc welding, however, the fluxing problem is not the same as in forge welding, for, to quote R. S. Kennedy,[2] "In electric arc welding with a metallic electrode, one great advantage is that, with exception of the atmosphere there are no impurities to guard against except such as are introduced in the materials. The source of heat is pure and it is necessary to see that the job is properly cleaned, and the metallic electrode of suitable material." It might be added that arc welding is essentially a fusion welding process, whereas in welding proper the metal is entirely in the plastic solid condition. The foremost fluxing problem in arc welding is the protection of the molten metal in the neighborhood of the arc from the atmosphere, and any substance introduced to achieve this end will be included under the name of flux, whether or not the substance is a flux in the true sense of the word. When the high temperatures which obtain in the arc are considered, it will be seen that to protect the arc is no very simple matter, for it is certain that part of the iron is vaporized and the highest temperature of the molten metal is only limited by the boiling point of iron.

As secondary considerations, a welding flux should contain substances of high thermionic emissivity, such as the oxides of the alkaline earths, which tend to yield a stable arc, giving a smooth running electrode, and also tend to localize the arc, thereby increas-

*A contribution to a general discussion on "Fluxes and Slags in Metal Melting and Working," held by the Faraday Society and the Institute of Metals with the cooperation of the British Non-Ferrous Metals Research Association and the Institute of British Foundrymen, on Monday, April 28, 1924.

ing its penetrating power. Moreover, the flux should consume evenly with the wire, and if producing a slag this should be limpid in character, for if it were viscous it would more easily be trapped in the weld. Other physical properties of the slag should also be attended to, so that there is least danger of the slag causing inclusions in the weld and blowholes.

In the voluminous patent literature of arc welding fluxes the most general claims of patentees are that the flux protects the deposited metal from oxidation during the welding process and at the same time yields a smooth working electrode, coupled with the special means by which the flux is applied, and fixed to the wire. Some also claim, in addition, to make good the loss of various constituents sustained by the electrode material in passing across the arc, and others claim to combine with the oxide in the deposit, which oxide passes into the removable slag instead of remaining in the weld, both of which claims rather appear to point to the incompleteness of the protection from atmospheric attack afforded by the flux. There is an old adage, "Prevention is better than cure," which the writer believes aptly applies to the protection of arc welded metal from contamination by oxygen and nitrogen.

With regard to published works on the use of flux in arc welding, attention is drawn to a paper by Prof. H. Neese,[3] which deals comprehensively with the craft. Part II of this paper devotes attention to tensile tests of welds made with various fluxes in comparison with tests of similar welds, made with the same quality of welding wire by the same operator under the same electrical conditions, but without flux. In all, he tried seven different fluxes, composed of various slag building and deoxidizing materials, and found that welds made with the flux-coated wire gave results, some higher and some lower than the bare wire welds. These results are given in condensed form in Tables I and II. The professor concludes "that the result of his experiments with flux coating is negative. No improvement of the structure of the deposited metal was observed in microscopic examination either by reducing the oxidation or eliminating slag inclusions or blowholes; on the contrary, the professor found that covering an electrode with flux influences the soundness of a weld unfavorably. Despite the greater unsoundness, however, the highest tensile strength was obtained with a flux-coated electrode, and the professor advises the use of flux from practical considerations in that it is considerably easier for a welder to hold a steady arc and flux enables him to make a smoother and more even weld; also impurities in the work metal are more easily melted out with the help of a molten flux. A welder seldom works under the easy conditions which obtain in making test pieces and he requires all the assistance a good flux can give in making his work easier."

Another paper, by W. E. Ruder,[4] deals with attempts to denitrogenize the weld metal by including in the wire elements with a

special affinity for nitrogen; the results were, however, negative. On this same question, Dr. Paterson[5] states that he has come across no weld, whether made with bare iron or flux-coated iron, that did not contain from 0.05 to 0.1 per cent of nitrogen. In a paper by J. Caldwell,[6] a table of a series of tests carried out by the Research Committee of the Emergency Fleet Corporation, U. S. A., comparing welds made under various processes, in which the best individual test was obtained with a bare mild steel wire. It would appear, therefore, that the findings of Professor Neese on the effect of flux in arc welding are generally supported by other workers in the craft, and that the demand for flux-coated wire for arc welding rests chiefly on practical considerations such as those put forward by Professor Neese, which are sound, coupled with a prejudice toward some form of protection, however imperfect, due to the knowledge that the metal in the arc requires protection. The writer believes there is more good to be derived from fluxing than the quoted references indicate. Dr. B. P. Haigh[7] gives a clue to this in two photo-micrographs, one showing a ferritic structure in a tough part of an arc weld and the other showing a laminated ferritic structure in the brittle part of the same weld, the weld presumably having been made with the same electrodes throughout.

The problem is whether the fluxing conditions can be manipulated so that a normally efficient welder is able to obtain tough metal throughout his weld.

With regard to the tensile test, a good welder, provided with suitable materials, can make a weld with either a fluxed or a bare wire, which will break well away from the weld, as illustrated by abstracts of tests given in Table III.

Further, the author's experience coincides with Professor Neese on the point that fluxes in general increase the number of blowholes and slag inclusions in the weld metal.

In a series of experiments made to discover the influence of flux coating on the ductility of arc deposited metal, small bars, 6 in. by ½ in. by ½ in., were built up with the arc and roughly ground up square and then bent by clamping in a vise and hammering the projecting end. With bare wire of various compositions the maximum bend obtained was 45 deg. and with wire of any definite composition successive tests yielded the same angle of bend to within a few degrees. With wire coated with various fluxes, angles of bend to the first crack of 5 deg. to 120 deg. were obtained, and on occasional instances almost 180 deg. were obtained.

In conclusion, the writer firmly believes that a suitable flux, manipulated by a conscientious and capable welder, gives a weld of superior mechanical properties, but, again quoting Mr. R. S. Kennedy,[8] "In arc welding, in common with all hand welding, a good job depends very largely on the conscientious work of the man."

My thanks are due to Mr. R. S. Kennedy for permission to give this paper, and to the Sir John Cass Institute, where some of the experiments were made.

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[1] See T. G. McKay's paper on "Electric Welding," *Trans. Liverpool Engineering Soc.*, Vol. XXXIX.
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TABLE I

ABSTRACTED FROM PROFESSOR H. NEESE'S PAPER, STAHL, EISEN, 1922.
TEST OF LAP WELDS

No.	Analysis of Powder	Result	Microscopic Examination
1	25 Carbon, $5Al_2$, O_2, 20 glass, 20 Ca, O, $10B_2$, O_7, $10SiO_2$, $10Na_2$, CO_3	41 per cent. strength	More blowholes, more slag inclusions, Nitride lines.
2	30 per cent. Ferro Silicon, 45 per cent. Si, 10 per cent. Ferro Manganese, 50 per cent. Mn, 15 per cent. Silicon, 5 per cent. Manganese added to Flux I	50-59 per cent. strength	As above.
3	35.5 Boric Acid, 50 NaCl, 27 Pot. Ferro Cyanide, 7.5 Rosin	61 per cent.	Blowholes, slag inclusion. Fewer nitride needles.
4	An American Flux, 10Mg, 5Al, 5C, 25MgO, 25CaO, $25SiO_2$. $5Na_2$, CO_3	55.9 per cent.	Free from large blowholes, numerous slag inclusions; structure comparatively free from acidularity.
5	40 Borax, 45 Glass, 15 Soda	57.7 per cent.	No large holes, numerous small slag inclusions.
6	$35H_3$, BO_3, 35CaO, 30C. Recommended as good by several sources	63.3 per cent	No special features.
7	Aluminium Magnesium added to 6 in same percentage as in No. 4	Lower strength	Usual features.
8	No Flux	59.5 per cent.	

TABLE II

TESTS OF BUTT WELDS, ABSTRACTED FROM PROFESSOR H. NEESE'S PAPER

Test No.	Flux	Yield Point, Kg.	Ultimate Strength, Kg.	Ultimate Strength, Kg. (per sq.mm.)	Ultimate Tons, Sq. Inch	Extension, Per Cent.	Contraction, in Area	Strength in Per Cent. Original Bar
1	None	7900	10600	35.5	22.54	8	12	83.8
2	Powder 1.7050	11600	36.9	23.4	8.5	15	92.2
3	Powder 6.7340	11600	36.9	23.4	8.7	21	92.2

TABLE III

TESTS OF WELDS MADE BY THE BRITISH ARC WELDING CO. IN ½-INCH MILD STEEL PLATE

No.		Ultimate Strength in Tons per Sq. Inch	Extension Per Cent in 8 Inches	Reduction of Area Per Cent	
1	Bare wire	25.4	26.1	56	Broke in solid
2	Fluxed Wire	25.7	20.2	51	Broke in solid
3	Fluxed Wire	30.2	20.0	35	Broke in solid

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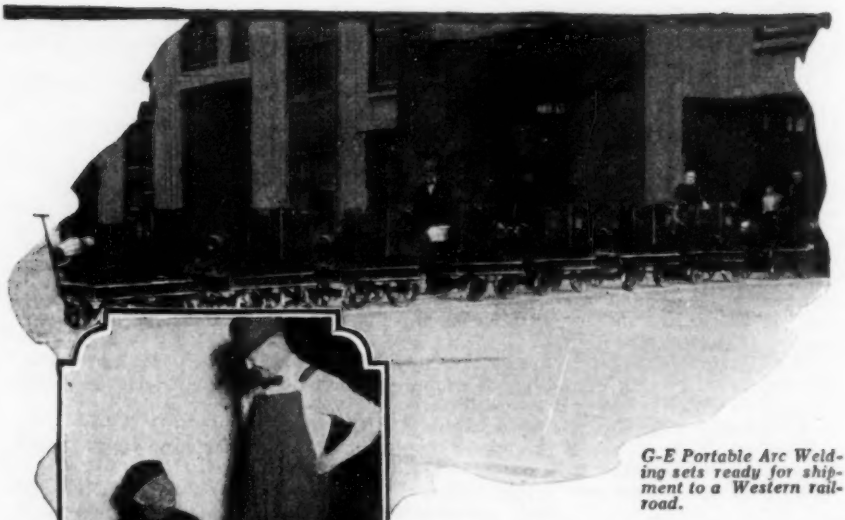

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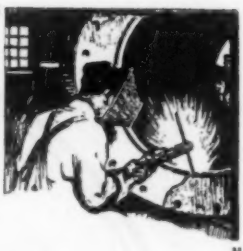

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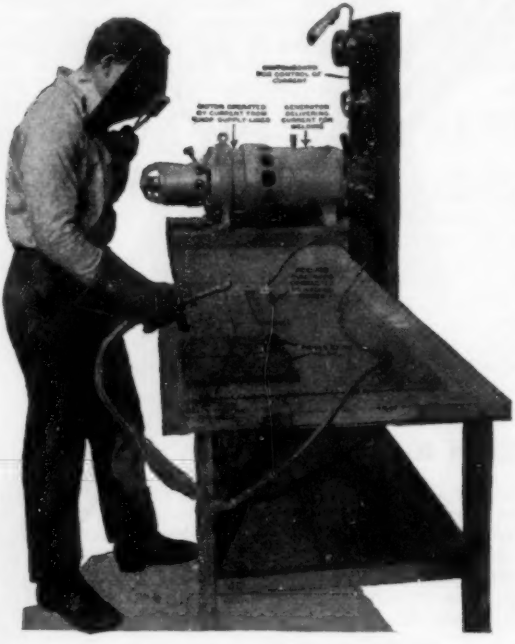

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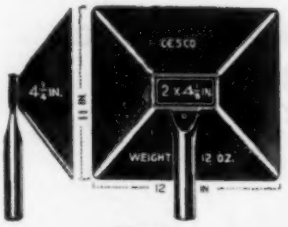

No. 10

CESCO HAND SHIELD

The illustration gives you full detail of size of Cesco Hand Shield No. 10.

Material—Black fibre formed to shape.
Lens—"Essentialite," the standard glass.
Lens Holder—Pressed metal fitted with spring tension for holding glass in place.
Handle—Fibre tube 7 inches in length allowing good space for grip.

Packed one in a box

Sold by all leading Jobbers, or Write Manufacturer

CHICAGO EYE SHIELD CO., 2300 Warren Ave., Chicago, Ill.

THERMIT WELDING

Only One Shrinkage in Thermit Welds

Where a weld cannot be made all in one layer, the shrinkage of the second and subsequent layers is resisted by those already solidified and shrinkage strains may result.

Up to a certain thickness, say 1 in., these strains will result in warping and the strains will thus be relieved; beyond this, the internal shrinkage strains will remain and early failure may result.

A Thermit weld is made in one operation regardless of the thickness of the section, and, therefore, there is only one shrinkage which can always be allowed for in advance.

Use Thermit for all heavy operations, such as locomotive frames.

METAL & THERMIT CORPORATION

120 Broadway, New York

PITTSBURGH CHICAGO BOSTON S. SAN FRANCISCO TORONTO

"THE UNIVERSAL WELDING MACHINE"

The Only Really Portable Machine

ARE YOU AWARE that our machine can be made to operate from any

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Electric Arc Cutting & Welding Co.

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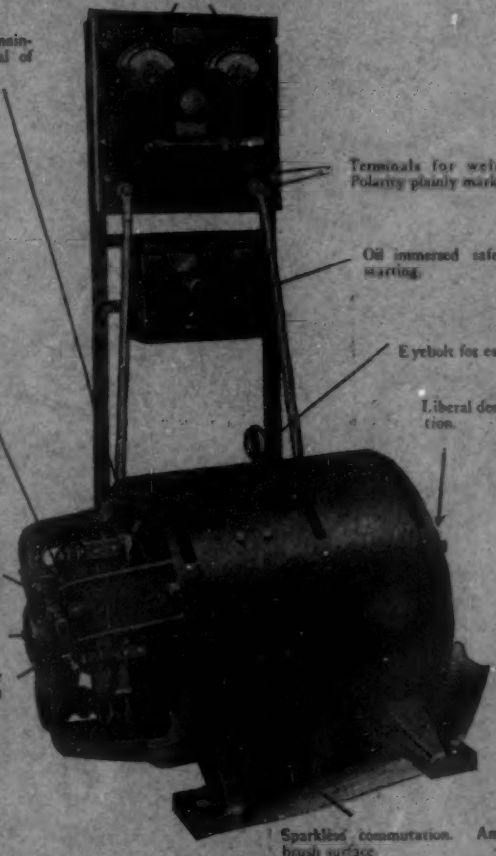
ELECTRIC ARC WELDING EQUIPMENTS


Voltmeter and ammeter furnished for indicating polarity and current. Meters are not necessary for regulating welding current.
Self exciting. No exciter to maintain. No accidental reversal of polarity.
Terminals for welding leads. Polarity plainly marked.
Oil immersed safety switch for starting.
Indicator plate and pointer shows settings and current values. Wide range of current regulation 50 to 300 amperes in an infinite number of steps.
Eyebolt for easy handling.
Liberal design. Rugged Construction.
Accurate and convenient regulation of welding current to value desired. Open circuit voltage practically constant throughout entire range.
Ball bearings
Current can be adjusted either before starting the set or while in operation.
Sparkless commutation. Ample brush surface.

Variable Voltage Type Equipment

BURKE ELECTRIC CO.

MAIN OFFICE AND WORKS, ERIE, PA.

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